CLAIMS

I/we claim:

[c1] 1. A method for controlling an intensity distribution of radiation directed to a microlithographic substrate, comprising:

directing a radiation beam from a radiation source along a radiation path, the radiation beam having a first distribution of intensity as a function of location in a plane generally transverse to the radiation path;

impinging the radiation beam on an adaptive structure positioned in the radiation path;

changing an intensity distribution of the radiation beam from the first distribution to a second distribution different than the first distribution by changing a state of a first portion of the adaptive structure relative to a second portion of the adaptive structure;

directing the radiation beam away from the adaptive structure along the radiation path; and

impinging the radiation beam directed away from the adaptive structure on the microlithographic substrate.

[c2] 2. The method of claim 1 wherein the adaptive structure includes a reflective surface having a first portion coupled to a first actuator and a second portion coupled to a second actuator, and wherein impinging the radiation beam includes impinging a first portion of the radiation beam on the first portion of the reflective surface and impinging a second portion of the radiation beam on the second portion of the reflective surface, and wherein changing a state of the first portion of the adaptive structure relative to a second portion of the adaptive structure includes moving the first portion of the reflective surface relative to the second portion of the reflective surface, and wherein the method further comprises:

reflecting at least part of the first portion of the radiation beam toward a portion of a grating having a first transmissivity and reflecting at least part of the second portion of the radiation beam toward a portion of the grating having a second transmissivity greater than the first transmissivity; and

passing at least part of the second portion of the radiation beam through the grating to impinge on the microlithographic substrate.

[c3] 3. The method of claim 1 wherein the microlithographic substrate is a first microlithographic substrate having a layer of radiation-sensitive material, and wherein the method further comprises:

passing the radiation beam with the second intensity distribution through a reticle and onto the radiation-sensitive material to form an image on the radiation sensitive material;

forming features in the first microlithographic substrate based on the image formed on the radiation sensitive material;

determining characteristics of the features formed in the first microlithographic substrate;

based on the determined characteristics, changing an intensity distribution of the radiation beam from the first distribution to a third distribution different than the first and second distributions by changing a state

of at least one of the first and second portions of the adaptive structure; and

impinging the radiation beam with the third intensity distribution on a second microlithographic substrate.

[c4] 4. The method of claim 1 wherein the adaptive structure includes a selectively transmissive medium, and wherein changing a state of the first portion of the adaptive structure relative to the second portion includes changing a transmissivity of the first portion to be different than a transmissivity of the second portion.

[c5] 5. The method of claim 1 wherein the adaptive structure includes a liquid crystal material, and wherein changing a state of the first portion of the adaptive structure relative to the second portion includes changing a transmissivity a first portion of the liquid crystal material relative to a transmissivity of a second portion of the liquid crystal material.

[c6] 6. The method of claim 1, further comprising:

passing the radiation beam through a reticle positioned between the adaptive structure and the microlithographic substrate to form an image on the microlithographic substrate; and

scanning the reticle and the microlithographic substrate relative to each other by moving the reticle along a reticle path generally normal to the radiation path proximate to the reticle and moving the microlithographic substrate along a substrate path in a direction opposite the reticle and generally normal to the radiation path.

[c7] 7. The method of claim 1, further comprising:

passing the radiation beam through a reticle positioned between the adaptive structure and the microlithographic substrate to form an image on the microlithographic substrate; and

stepping the microlithographic substrate and the reticle relative to each other by impinging the radiation on a first field of the microlithographic substrate while the microlithographic substrate is in a first fixed transverse alignment relative to the reticle, moving at least one of the reticle and the microlithographic substrate transversely relative to the other to align a second field with the reticle, and exposing the second field to the radiation while the microlithographic substrate is in a second fixed transverse alignment relative to the reticle.

[c8] 8. The method of claim 1 wherein changing the intensity distribution of the radiation beam includes changing each portion of the second distribution by no more than about ten percent relative to the corresponding portion of the first distribution.

[c9] 9. The method of claim 1 wherein changing the intensity distribution of the radiation beam includes changing each portion of the second distribution by no more than about five percent relative to the corresponding portion of the first distribution.

[c10] 10. The method of claim 1 wherein impinging the radiation beam with the second intensity distribution on the microlithographic substrate includes irradiating a first portion of the microlithographic substrate with radiation at a first intensity and irradiating a second portion of the microlithographic substrate with radiation at a second intensity, the second portion of the microlithographic

substrate being spaced apart from the first portion of the microlithographic substrate by a distance of about 0.3 millimeters or greater.

[c11] 11. The method of claim 1 wherein the radiation beam has an average intensity after impinging on the adaptive structure, and wherein impinging the radiation beam on the microlithographic substrate includes impinging radiation with a higher than average intensity on a first field of the microlithographic substrate and impinging radiation with a lower than average intensity on a second field of the microlithographic substrate.

[c12] 12. The method of claim 1 wherein the radiation beam has an average intensity after impinging on the adaptive structure, and wherein impinging the radiation beam on the microlithographic substrate includes impinging radiation with a higher than average intensity on a first die of the microlithographic substrate and impinging radiation with a lower than average intensity on a second die of the microlithographic substrate.

[c13] 13. The method of claim 1, further comprising changing a shape of the radiation beam after impinging the radiation beam on the adaptive structure.

[c14] 14. The method of claim 1 wherein impinging the radiation beam on the microlithographic substrate includes impinging the radiation beam on a photosensitive layer of the microlithographic substrate.

[c15] 15. A method for controlling an intensity distribution of radiation directed to a microlithographic substrate, comprising:

directing a radiation beam from a radiation source along a radiation path toward a microlithographic substrate;

impinging a first portion of the radiation beam on a first portion of a selectively transmissive medium and impinging a second portion of

the radiation beam on a second portion of the selectively transmissive medium;

changing a transmissivity of at least one of the first and second portions of the selectively transmissive medium relative to the other;

passing at least part of at least one of the first and second portions of the radiation beam through the selectively transmissive medium to impinge on the microlithographic substrate, while at least inhibiting passage of at least part of the other of the first and second portions of the radiation beam through the selectively transmissive medium; and

directing the radiation beam away from the selectively transmissive medium along the radiation path to impinge on the microlithographic substrate.

[c16] 16. The method of claim 15 wherein the radiation beam has a first intensity distribution upon impinging on the selectively transmissive medium, and wherein the method further comprises changing an intensity distribution of the radiation beam directed away from the selectively transmissive medium to a second intensity distribution different than the first distribution by changing a transmissivity of at least one of the first and second portions of the selectively transmissive medium relative to the other.

[c17] 17. The method of claim 15 wherein impinging the radiation on a selectively transmissive medium includes impinging the radiation on a liquid crystal material, and wherein changing a transmissivity includes changing the first portion of the selectively transmissive medium to be opaque.

[c18] 18. The method of claim 15 wherein impinging the radiation on a selectively transmissive medium includes impinging the radiation on a liquid crystal material, and wherein changing a transmissivity includes reducing the transmissivity of the

first portion of the selectively transmissive medium without making the first portion opaque.

[c19] 19. The method of claim 15, further comprising selecting the radiation beam to have a wavelength of about 365 nanometers or less.

[c20] 20. The method of claim 15 wherein impinging the radiation beam on the microlithographic substrate includes impinging the radiation beam on a radiation-sensitive material of the microlithographic substrate.

[c21] 21. The method of claim 15 wherein impinging the radiation beam on the microlithographic substrate includes impinging the radiation beam on a photoresist layer of the microlithographic substrate.

[c22] 22. A method for controlling an intensity distribution of radiation directed to a microlithographic substrate, comprising:

directing a radiation beam from a radiation source along a radiation path toward a microlithographic substrate;

impinging a first portion of the radiation beam on a first portion of the reflective medium and impinging a second portion of the radiation beam on a second portion of the reflective medium;

moving the first portion of the reflective medium relative to the second portion of the reflective medium;

reflecting at least part of the first portion of the radiation beam toward a first portion of a grating having a first transmissivity and reflecting at least part of the second portion of the radiation beam toward a second portion of the grating having a second transmissivity greater than the first transmissivity; and

passing at least part of the second portion of the radiation beam through the grating to impinge on the microlithographic substrate while

attenuating and/or blocking at least part of the first portion of the radiation beam from passing through the grating.

[c23] 23. The method of claim 22 wherein the radiation beam has a first intensity distribution upon impinging on the reflective medium, and wherein the method further comprises changing an intensity distribution of the radiation beam passing through the grating to a second intensity distribution different than the first distribution.

[c24] 24. The method of claim 22 wherein the microlithographic substrate has a layer of radiation-sensitive material and wherein passing the radiation through the grating to impinge on the microlithographic substrate includes directing the first portion of the radiation to impinge on the radiation-sensitive material.

[c25] 25. The method of claim 22, further comprising selecting the grating to have an open area of at least about 90 percent.

[c26] 26. The method of claim 22 wherein moving the first portion of the reflective medium relative to the second portion of the reflective medium includes tilting a reflective surface of the first portion relative to the radiation path to an angle different than an angle between the radiation path and a reflective surface of the second portion.

[c27] 27. The method of claim 22, further comprising absorbing radiation incident on the first portion of the grating with absorbent material on the opaque portion of the grating.

[c28] 28. The method of claim 22, further comprising selecting the radiation beam to have a wavelength of about 365 nanometers or less.

[c29] 29. A method for controlling an intensity distribution of radiation directed to a microlithographic substrate, comprising:

directing a radiation beam from a radiation source along a radiation path toward a microlithographic substrate, the radiation beam having a first intensity distribution in a plane generally normal to the radiation path;

impinging a first portion of the radiation beam on a first portion of a reflective medium and impinging a second portion of the radiation beam on a second portion of the reflective medium;

changing an intensity distribution of the radiation beam from the first distribution to a second distribution by inclining the first portion of the reflective medium relative to the second portion of the reflective medium to direct the first portion of the radiation at a first angle relative to the radiation path and direct the second portion of the radiation at a second angle relative to the radiation path, the second angle being different than the first angle; and

impinging the radiation with the second intensity distribution on the microlithographic substrate.

[c30] 30. The method of claim 29, further comprising smoothing the second distribution of intensity by passing the radiation beam through a diffuser after impinging the radiation beam on the reflective surface and before impinging the radiation beam on the microlithographic substrate.

[c31] 31. The method of claim 29, further comprising passing the radiation beam through a reticle before impinging the radiation beam on the microlithographic substrate.

[c32] 32. The method of claim 29 wherein changing the intensity includes decreasing the intensity in one region of the radiation beam and increasing the intensity in

another region of the radiation beam by directing some of the radiation away from the one region and into the other region.

[c33] 33. The method of claim 29 wherein the microlithographic substrate has a layer of radiation-sensitive material and wherein impinging the radiation beam on the microlithographic substrate includes impinging the radiation beam on the radiation-sensitive material.

[c34] 34. The method of claim 29, further comprising selecting the radiation beam to have a wavelength of about 365 nanometers or less.

[c35] 35. A method for controlling intensity distributions of radiation directed to microlithographic substrates, comprising:

directing a radiation beam from a radiation source along a radiation path toward a first microlithographic substrate;

forming an image on a surface of the microlithographic substrate;

based on the image, forming a feature of the microlithographic substrate;

determining a difference between a characteristic of the feature and a target characteristic;

based on the difference between the characteristic of the feature and the target characteristic, determining a difference between an intensity distribution of radiation impinging on the first microlithographic substrate and a target intensity distribution;

at least partially reducing the difference between the intensity distribution and the target intensity distribution by positioning an adaptive structure in the radiation path and changing a state of a first portion of the adaptive structure relative to a second portion of the adaptive structure to redirect at least part of the radiation; and

directing radiation from the radiation source along the radiation path to impinge on the adaptive structure and a second microlithographic substrate.

[c36] 36. The method of claim 35 wherein forming an image on a surface of the microlithographic substrate includes forming an image on a radiation-sensitive material of the microlithographic substrate.

[c37] 37. The method of claim 35 wherein forming a feature of the microlithographic substrate includes forming a conductive structure of the microlithographic substrate, and wherein determining a difference between a characteristic of the feature and a target characteristic includes determining a difference between a conductivity of the conductive structure and a target conductivity.

[c38] 38. The method of claim 35 wherein determining a difference between a characteristic of the feature and a target characteristic includes determining a difference between a dimension of the feature and a target dimension.

[c39] 39. The method of claim 35 wherein determining a difference between a characteristic of the feature and a target characteristic includes determining a difference in a characteristic of an etched feature.

[c40] 40. The method of claim 35 wherein determining a difference between a characteristic of the feature and a target characteristic includes determining a difference caused by passing the radiation beam through a reticle.

[c41] 41. The method of claim 35 wherein the adaptive structure includes a reflective surface having a first portion coupled to a first actuator and a second portion coupled to a second actuator, and wherein impinging the radiation beam includes impinging a first portion of the radiation beam on the first portion of the reflective

surface and impinging a second portion of the radiation beam on the second portion of the radiation surface, and wherein changing a state of the first portion of the adaptive structure relative to a second portion of the adaptive structure includes moving the first portion of the reflective surface relative to the second portion of the reflective surface, and wherein the method further comprises:

reflecting at least part of the first portion of the radiation beam toward a first portion of a grating having a first transmissivity and reflecting at least part of the second portion of the radiation beam toward a second portion of the grating having a second transmissivity greater than the first transmissivity; and

passing at least part of the second portion of the radiation beam through the grating to impinge on the microlithographic substrate.

[c42] 42. The method of claim 35 wherein the adaptive structure includes a selectively transmissive medium, and wherein changing a state of the first portion of the adaptive structure relative to the second portion includes changing a transmissivity of the first portion to be different than a transmissivity of the second portion.

[c43] 43 . The method of claim 35 wherein the adaptive structure includes a liquid crystal material, and wherein changing a state of the first portion of the adaptive structure relative to the second portion includes changing a transmissivity a first portion of the liquid crystal material relative to a transmissivity of a second portion of the liquid crystal material.

[c44] 44. The method of claim 35, further comprising:

passing the radiation beam through a reticle positioned between the adaptive structure and the microlithographic substrate to form an image on the microlithographic substrate; and

scanning the reticle and the microlithographic substrate relative to each other by moving the reticle along a reticle path generally normal to the radiation path proximate to the reticle and moving the microlithographic substrate along a substrate path in a direction opposite the reticle and generally normal to the radiation path.

[c45] 45. The method of claim 35, further comprising:

passing the radiation beam through a reticle positioned between the adaptive structure and the microlithographic substrate to form an image on the microlithographic substrate; and

stepping the microlithographic substrate and the reticle relative to each other by impinging the radiation beam on a first field of the microlithographic substrate while the microlithographic substrate is in a first fixed transverse alignment relative to the reticle, moving at least one of the reticle and the microlithographic substrate transversely relative to the other to align a second field with the reticle, and exposing the second field to the radiation beam while the microlithographic substrate is in a second fixed transverse alignment relative to the reticle.

[c46] 46. An apparatus for controlling an intensity distribution of radiation directed to a microlithographic substrate, comprising:

a substrate support having a support surface positioned to carry a microlithographic substrate;

a source of radiation positioned to direct a radiation beam along a radiation path toward the substrate support;

an adaptive structure positioned in the radiation path and configured to receive the radiation beam with a first intensity distribution and transmit the radiation beam with a second intensity distribution different than the first intensity distribution, the adaptive structure

having a first portion and a second portion, each positioned to receive the radiation and each changeable from a first state to a second state, and wherein the adaptive structure is configured to transmit the radiation with the second intensity distribution when the first portion is in the first state and the second portion is in the second state; and

a controller operatively coupled to the adaptive structure to direct at least one of the first and second portions to change from the first state to the second state to change an intensity distribution of the radiation beam from the first intensity distribution to the second intensity distribution.

[c47] 47. The apparatus of claim 46 wherein the adaptive structure includes a selectively transmissive medium having a first portion aligned with a first portion of the radiation beam when the radiation beam is emitted from the radiation source, and a second portion aligned with a second portion of the radiation beam when the radiation beam is emitted by the radiation source, each of the first and second portions of the selectively transmissive medium having a transmissivity that is changeable from a first transmissivity to a second transmissivity different than the first transmissivity

[c48] 48. The apparatus of claim 46 wherein the adaptive structure includes a liquid crystal material having first and second portions, each with a transmissivity that is changeable from a first transmissivity to a second transmissivity different than the first transmissivity.

[c49] 49. The apparatus of claim 46 wherein the adaptive structure includes a reflective medium having a first portion aligned with a first portion of the radiation beam when the radiation beam is emitted from the radiation source, the reflective medium having a second portion aligned with a second portion of the radiation

beam when the radiation beam is emitted by the radiation source, each of the first and second portions of the reflective medium being coupled to at least one actuator to move from a first inclination angle relative to the radiation path to a second inclination angle relative to the radiation path, the second inclination angle being different than the first inclination.

[c50] 50. The apparatus of claim 46 wherein the adaptive structure includes a reflective medium having a first portion aligned with a first portion of the radiation beam when the radiation beam is emitted from the radiation source, the reflective medium having a second portion aligned with a second portion of the radiation beam when the radiation beam is emitted by the radiation source, each of the first and second portions of the reflective medium being coupled to at least one actuator to move from a first inclination angle relative to the radiation path to a second inclination angle relative to the radiation path, the second inclination angle being different than the first inclination angle, and wherein the apparatus further comprises:

a grating positioned between the adaptive structure and the substrate support, the grating having a first region with a first transmissivity and being optically aligned with the first portion of the reflective medium to receive at least part of the first portion of the radiation beam when the first portion of the reflective medium has the first inclination angle relative to the radiation path, the grating further having a second region with a second transmissivity greater than the first transmissivity and being optically aligned with the first portion of the reflective medium to receive at least part of the first portion of the radiation beam when the first portion of the reflective medium has the second inclination angle relative to the radiation path.

[c51] 51. The apparatus of claim 46, further comprising a reticle positioned between the adaptive structure and the substrate support, the reticle having at least one reticle aperture positioned to pass the radiation toward the substrate support.

[c52] 52. The apparatus of claim 46, further comprising a reticle having a reticle aperture positioned to pass radiation toward the substrate support, the reticle being coupled to a reticle actuator to move along a reticle path generally normal to the radiation path proximate to the reticle, and wherein the support member is coupled to a support member actuator to move along a support member path in a direction opposite the reticle and generally normal to the radiation path while the reticle moves along the reticle path.

[c53] 53. The apparatus of claim 46, further comprising a reticle having a reticle aperture positioned to pass radiation toward the substrate support, and wherein at least one of the support member and the reticle is coupled to at least one actuator to sequentially align fields of the microlithographic substrate with the radiation beam when the microlithographic substrate is carried by the support member.

[c54] 54. An apparatus for irradiating a microlithographic substrate, comprising:

a substrate support having a support surface positioned to carry a microlithographic substrate;

a radiation source positioned to direct a radiation beam along a radiation path toward the substrate support;

a selectively transmissive medium positioned in the radiation path, the selectively transmissive medium having a first portion aligned with a first portion of the radiation beam when the radiation beam is emitted from the radiation source, the selectively transmissive medium having a second portion aligned with a second portion of the radiation beam when the radiation beam is emitted by the radiation source, each of the first and second portions of the

selectively transmissive medium having a transmissivity that is changeable from a first transmissivity to a second transmissivity different than the first transmissivity; and

a controller operatively coupled to the selectively transmissive medium to direct at least one of the first and second portions to change from the first transmissivity to the second transmissivity.

[c55] 55. The apparatus of claim 46 wherein the selectively transmissive medium includes a liquid crystal material.

[c56] 56. The apparatus of claim 46 wherein the first portion is configured to change to the second transmissivity without becoming opaque.

[c57] 57. The apparatus of claim 46 wherein the radiation source is configured to emit a radiation beam having a wavelength of about 365 nanometers or less.

[c58] 58. The apparatus of claim 46, further comprising a reticle having a reticle aperture positioned to pass radiation toward the substrate support, the reticle being coupled to a reticle actuator to move along a reticle path generally normal to the radiation path proximate to the reticle, and wherein the support member is coupled to a support member actuator to move along a support member path in a direction opposite the reticle and generally normal to the radiation path while the reticle moves along the reticle path.

[c59] 59. The apparatus of claim 46, further comprising a reticle having a reticle aperture positioned to pass radiation toward the substrate support, and wherein at least one of the support member and the reticle is coupled to at least one actuator to sequentially align fields of the microlithographic substrate with the radiation beam when the microlithographic substrate is carried by the support member.

[c60] 60. An apparatus for irradiating a microlithographic substrate, comprising:

a substrate support having a support surface positioned to carry a microlithographic substrate;

a radiation source positioned to direct a radiation beam along a radiation path toward the substrate support;

a reflective medium positioned in the radiation path, the reflective medium having a first portion aligned with a first portion of the radiation beam when the radiation beam is emitted from the radiation source, the reflective medium having a second portion aligned with a second portion of the radiation beam when the radiation beam is emitted by the radiation source, each of the first and second portions of the reflective medium being movable from a first inclination angle relative to the radiation path to a second inclination angle relative to the radiation path, the second inclination angle being different than the first inclination angle;

a grating positioned between the reflective medium and the substrate support, the grating having a first region with a first transmissivity and being optically aligned with the first portion of the reflective medium to receive the first portion of the radiation beam when the first portion of the reflective medium has the first inclination angle relative to the radiation path, the grating further having a second region with a second transmissivity greater than the first transmissivity and being optically aligned with at least part of the first portion of the reflective medium to receive the first portion of the radiation beam when the first portion of the reflective medium has the second inclination angle relative to the radiation path; and

a controller operatively coupled to the reflective medium to direct at least one of the first and second portions to change from the first inclination angle to the second inclination angle.

[c61] 61. The apparatus of claim 60 wherein the grating has at least approximately 90 percent open area.

[c62] 62. The apparatus of claim 60 wherein the radiation source is configured to emit a radiation beam having a wavelength of about 365 nanometers or less.

[c63] 63. The apparatus of claim 60, further comprising a reticle having a reticle aperture positioned to pass radiation toward the substrate support, the reticle being coupled to a reticle actuator to move along a reticle path generally normal to the radiation path proximate to the reticle, and wherein the support member is coupled to a support member actuator to move along a support member path in a direction opposite the reticle and generally normal to the radiation path while the reticle moves along the reticle path.

[c64] 64. The apparatus of claim 60, further comprising a reticle having a reticle aperture positioned to pass radiation toward the substrate support, and wherein at least one of the support member and the reticle is coupled to at least one actuator to sequentially align fields of the microlithographic substrate with the radiation beam when the microlithographic substrate is carried by the support member.

[c65] 65. An apparatus for irradiating a microlithographic substrate, comprising:

a substrate support having a support surface positioned to carry a microlithographic substrate;

a radiation source positioned to direct a radiation beam along a radiation path toward the substrate support;

a reflective medium positioned in the radiation path and configured to receive the radiation beam with a first intensity distribution and transmit the radiation beam with a second intensity distribution different than the first intensity distribution, the reflective medium having a first portion aligned with a first portion of the radiation

beam when the radiation beam is emitted from the radiation source, the reflective medium having a second portion aligned with a second portion of the radiation beam when the radiation beam is emitted by the radiation source, each of the first and second portions of the reflective medium being movable from a first inclination angle relative to the radiation path to a second inclination angle relative to the radiation path, the second inclination angle being different than the first inclination angle;

a reticle positioned between the reflective medium and the substrate support to receive the radiation beam from the reflective medium, the reticle having at least one aperture positioned to project an image onto the microlithographic substrate when the microlithographic substrate is carried by the substrate support; and

a controller operatively coupled to the reflective medium to direct at least one of the first and second portions to change from the first inclination angle to the second inclination angle.

[c66] 66. The apparatus of claim 65, further comprising a diffuser element positioned between the reflective medium and the reticle to smooth a distribution of radiation intensity of the radiation beam reflected from the reflective medium.

[c67] 67. The apparatus of claim 65 wherein the radiation source is configured to emit a radiation beam having a wavelength of about 365 nanometers or less.

[c68] 68. The apparatus of claim 65 wherein the reticle is coupled to a reticle actuator to move along a reticle path generally normal to the radiation path proximate to the reticle, and wherein the support member is coupled to a support member actuator to move along a support member path in a direction opposite the reticle and generally normal to the radiation path while the reticle moves along the reticle path.

[c69] 69. The apparatus of claim 65 wherein at least one of the support member and the reticle is coupled to at least one actuator to sequentially align fields of the microlithographic substrate with the radiation beam when the microlithographic substrate is carried by the support member.